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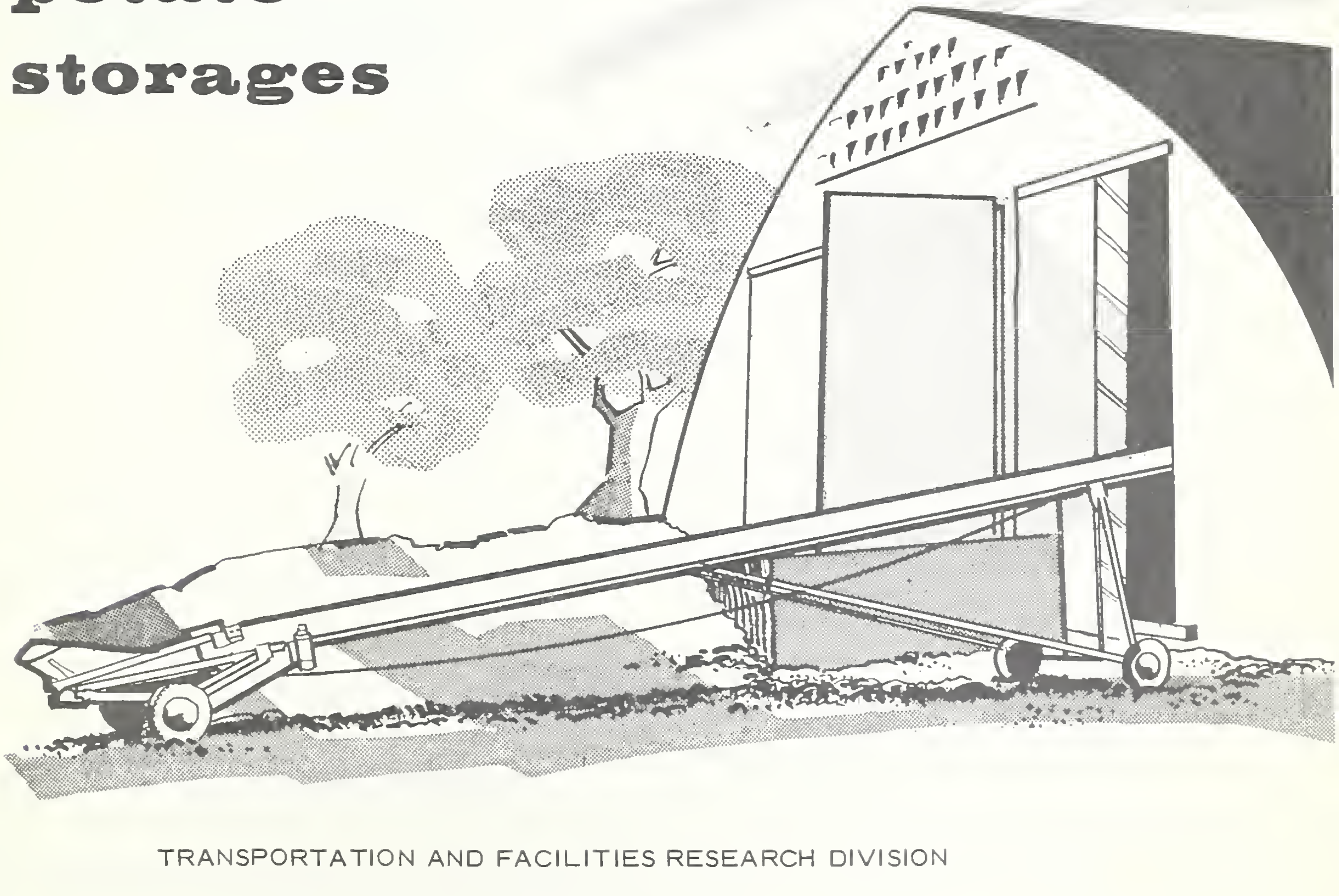
A LIGHT-WEIGHT CONVEYOR for filling deep-bin potato storages



TRANSPORTATION AND FACILITIES RESEARCH DIVISION

AND

MARKET QUALITY RESEARCH DIVISION

PREFACE

This report is based upon research conducted at the Red River Valley Potato Research Center, East Grand Forks, Minn., and is part of a larger research project covering the development of more efficient work methods, equipment, and facilities for off-farm handling, sorting, cleaning, grading, sizing, and packing fall crop potatoes. The conveyor described in this report was developed, built, and tested at the Research Center. The research that formed the basis for developing this potato-handling equipment was conducted by the Agricultural Marketing Service.

The authors wish to acknowledge the special contribution of the late Grimsi Goodman, potato grower at Milton, N. Dak. Mr. Goodman greatly encouraged the initial development of the method in which this lightweight conveyor is used, and was first to adopt it commercially. The method and equipment were developed under the direct supervision of Alfred D. Edgar, agricultural engineer, Transportation and Facilities Research Division. Archie H. Glaves, agricultural engineer, and Albert J. Dubuque, engineering aid, Agricultural Engineering Research Division, Agricultural Research Service, provided valuable assistance and cooperation in developing this and preceding models of trough belt potato conveyors.

John C. Hansen, horticulturist, formerly of the Market Quality Research Division, assisted in conducting studies of injury to potatoes when the method and equipment were tested. (Mr. Hansen is now with the North Dakota Agricultural College.)

This study is part of a broad program of research designed to improve efficiency and reduce costs in the marketing of farm products.

CONTENTS

Page

Summary 3
Background. 3
Mechanical injury of potatoes 6
Description of equipment. 7
  Structural modification required. 7
  Ceiling track installation. 7
  Description of conveyor 7
  Operation of conveyor 8
  Construction details. 14
  Construction materials. 14
Conclusions and recommendations 15

February 1960

A LIGHTWEIGHT CONVEYOR
for
FILLING DEEP-BIN POTATO STORAGES

By R. S. Claycomb, agricultural engineer
Transportation and Facilities Research Division
and
Herbert Findlen, horticulturist,
Market Quality Research Division
Agricultural Marketing Service

SUMMARY

A 40-foot conveyor supported from a ceiling track has been developed for use in filling deep-bin potato storages. The conveyor is the latest result of a research program to develop improved methods and equipment to move potatoes into deep-bin storages typical of those found in the Red River Valley of North Dakota and Minnesota, as a means of reducing marketing costs for potatoes. The program was begun in 1949 at the Red River Valley Research Center, East Grand Forks, Minn.

By the use of this conveyor, potatoes can be placed in storage at the rate of 12 hundredweight (cwt.) per minute, or a truckload (120 cwt. of potatoes) in 10 minutes. In this respect it compares favorably with the best of the currently used commercial methods. Two men can operate it most of the time, but 3 workers are needed for about one-half hour during each of the 4 times the conveyor must be shifted when filling a 4-bin, 50,000-cwt. storage.

The cost of approximately $1,700 for this conveyor and auxiliary equipment compares favorably with the cost of other equipment used to fill modern above-ground storages.

The belt conveyor is troughed and has no side rails to scuff potatoes. In tests conducted in filling 20-foot-deep storage bins, this conveyor caused injuries in 5 to 20 percent of the potatoes, but only one-quarter to 1 percent were injured sufficiently to put them out of the U. S. No. 1 grade. These percentages represent less than half as much injury as on comparable potatoes handled by the conventional canvas chute.

BACKGROUND

The Red River Valley of North Dakota and Minnesota is a potato-producing area that annually ships approximately 10,000,000 cwt. or 28,000 carload equivalents (360 cwt. per carload) of potatoes. 1/ This volume includes seed

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1/ Based on total area inspections recorded in the office of the Red River Valley Potato Control Board, 1957-58 season.

potatoes, table stock, and potatoes for processing, most of which are held in storage for winter marketing. About one-third of these potatoes are held in storage structures similar to the one shown in figure 1.

In the 1930's and 1940's, many structures of this type with capacities of 20,000 to 50,000 cwt. were built and are still in fairly good repair. Because the storage bins are 10 to 20 feet underground where the year-round temperature is close to 40° F., they provide ideal storage temperature during the long cold winters of this area. But despite their generally sound structural condition and other good attributes, they are losing favor because of changes in potato-handling methods. Mechanical harvesting, bulk trucks with built-in conveyors, and high-piling conveyors have made above-ground storages more popular.

In many deep-bin storages, canvas chutes are commonly used to lower potatoes from ground level down into the bins (fig. 2). Handling methods such as this can be expected to injure about 2 to 4 percent of the potatoes sufficiently to throw them out of the U. S. No. 1 grade. In addition, the chute often scuffs the other potatoes so as to detract from their appearance when they are later offered for sale.

A major line of research at the Red River Valley Potato Research Center was concerned with the development of improved methods and equipment for filling deep-bin potato storages. A lightweight conveyor, 40 feet long and supported from a ceiling track during bin-filling operations, is the latest method developed for deep-bin filling.

In tests with this conveyor four requirements were to be met. These were: (1) Capacity of the conveyor should permit a truckload of potatotes to be placed in storage in 10 to 15 minutes; (2) the equipment and method should be simple and suitable for use by unskilled workers; (3) the cost should be competitive with existing equipment and methods; and (4) potatoes handled with this conveyor should receive fewer injuries than with existing methods and equipment.

This lightweight, 40-foot conveyor, suspended from a ceiling track, fulfills these requirements.

It places potatoes in storage at the rate of a 120-cwt. truckload in 10 minutes of operating time, comparing favorably with the best of conventional methods.

It is simple to operate and can be handled by one man plus a truck-unloading operator most of the time. During 4 major moves required to fill a 4-bin, 50,000-cwt. storage, the 2 men need the help of another truck operator for about half an hour to move hoist and conveyor to another track.

The cost in 1957 of a custom-made 40-foot conveyor built in accordance with plans given in this report was $1,400. Companion equipment, the hoist, costs $200; the ceiling track, installed, costs $3 per foot.

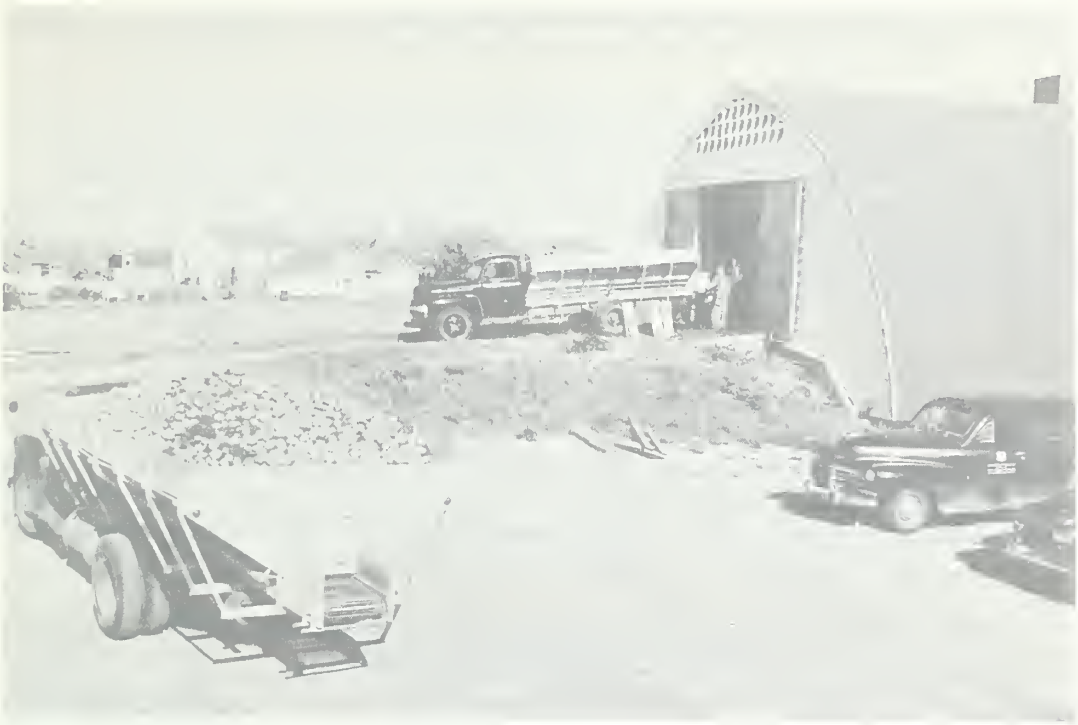

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Figure 1.--A Red River Valley area deep-bin potato storage.

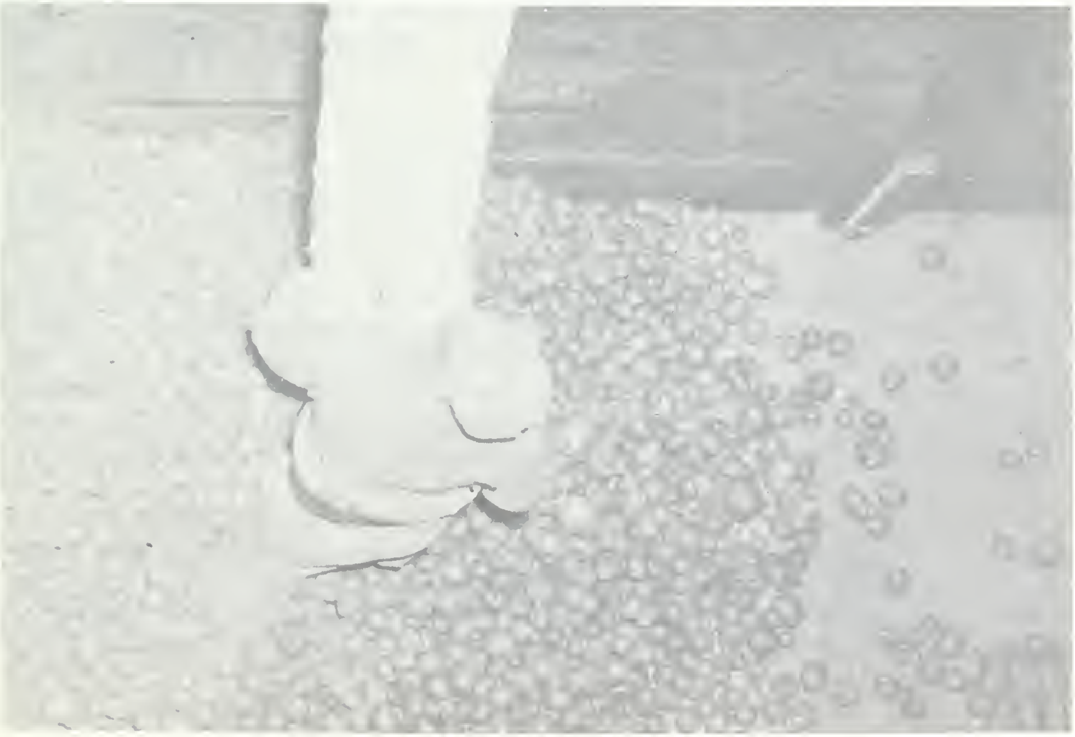

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Figure 2.--A canvas chute being used to lower potatoes into a deep-bin.

Injury to potatoes attributable to this method and equipment is small compared to injury caused by the canvas chute method.

A floor-supported bin loader, adapted to truck unloading within the bin and filling the bin from the floor to a depth of 14 feet, costs about the same as the custom-made 40-foot conveyor alone. The cost of the hoist and ceiling track is additional. However, the floor-supported bin filler is not adapted to filling deep bins from floor to ceilings above 14 feet, but the ceiling-supported conveyor is suitable to both deep-bin and within-the-bin filling.

MECHANICAL INJURY OF POTATOES

Bruising or injury tests were conducted during the 1957-58 and 1958-59 seasons to compare the performance of the lightweight conveyor with that of the conventional methods which employs a conveyor and a canvas chute in filling deep bins. Results of these tests are shown in table 1.

Table 1.--Potatoes injured in bin-filling tests with two kinds of equipment, 1957-58 and 1958-59 seasons

Equipment	1957-58 season		1958-59 season	
	Slight injuries not affecting grade	Injuries that reduce grade	Slight injuries not affecting grade	Injuries that reduce grade
	Percent	Percent	Percent	Percent
Lightweight, 40-foot conveyor	5.8	0.2	19.7	0.9
Conveyor and canvas chute . .	16.3	.7	37.3	2.2

Based on these tests, the lightweight 40-foot conveyor caused about one-half to one-third as many slight injuries (within the tolerance of U. S. No. 1 grade) as the conventional canvas chute. Small injuries, although they do not affect the grade, do affect the appearance and frequently function as entryways for organisms which may cause excessive decay in storage or in transit. Therefore even small injuries should be avoided where possible.

The potatoes used in these tests during the 1957-58 season were probably not as susceptible to bruising as those used in the 1958-59 tests. In addition large quantities of damp soil adhered to the tubers during 1957 harvest and may have functioned as padding, thus reducing the amount of bruising.

DESCRIPTION OF EQUIPMENT

Structural Modification Required

In many conventional deep-bin potato storage houses certain structural modifications must be made before the ceiling-supported conveyor method can be adopted. Generally, it will be necessary to (1) remove bin partitions and drive floor, (2) assure that the posts and other roof supports are structurally sound, and (3) cut one or more slots in the end wall as shown in figure 3 to receive the conveyor.

It is frequently less costly to remove rotted or deteriorated drive floors and bin partitions than it is to make them sound enough to carry trucks loaded with potatoes. Removing these items entirely may increase the storage capacity by 10 to 20 percent, depending upon the type of structure, the thickness and number of bin walls, width of the drive, or other factors.

Ceiling Track Installation

An overhead hay-type track is attached to the ceiling structure running the length of the storage house. The track should be centered over the length of the bin. A trolley riding on this track carries a 1-ton-capacity electric hoist to which the delivery end of the conveyor is attached. The hoist raises and lowers the delivery end of the conveyor (fig. 4), permitting minimum drops near the floor as well as at the top of the pile.

Description of Conveyor

Instead of a fabricated frame consisting of many pieces of mild steel angles and bars welded together, the frame of the conveyor is a 40-foot-long tube, or spine, of cold-drawn steel. All the accessories are clamped to this spine--nothing is welded to it to diminish the strength in the vicinity of welds. This type of design was adopted to minimize the weight of the conveyor and yet have a frame of adequate strength. A neoprene belt without flights carries potatoes in the trough created by troughing rollers spaced at intervals along the conveyor. A 3-phase, 60-cycle, 2-horsepower, 220-volt motor drives the belt by means of a speed jack and speed reducer which turns the drive pulley at 150 r.p.m.

The ground support at the receiving end is detachable and the rear wheels adjust up and down to fit the flexible hopper to the truck. Originally placed above the conveyor, the motor and speed-reducing mechanism were later suspended beneath the delivery end for improved stability and appearance.

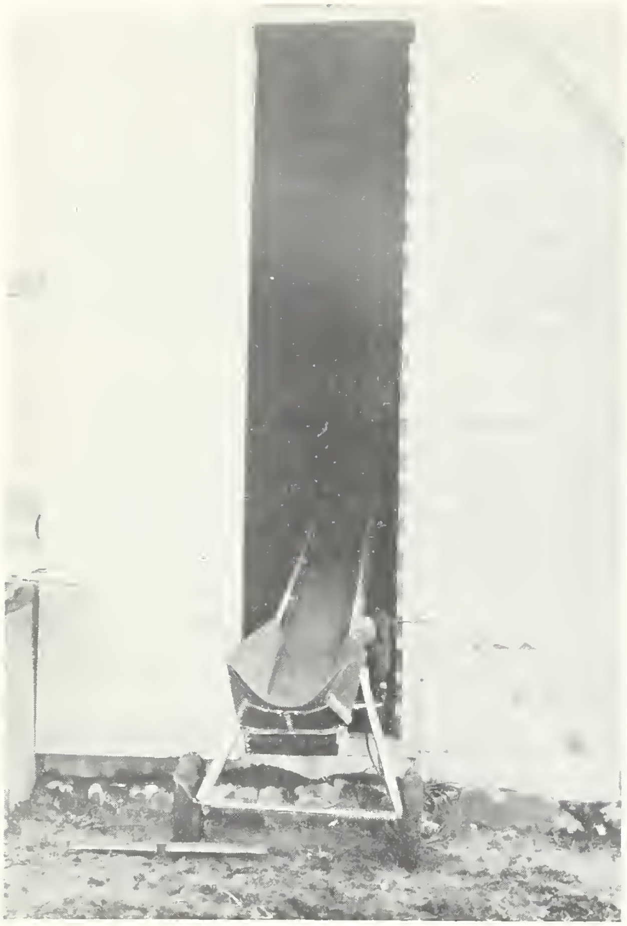

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Figure 3.--Slot cut in end wall to admit conveyor.

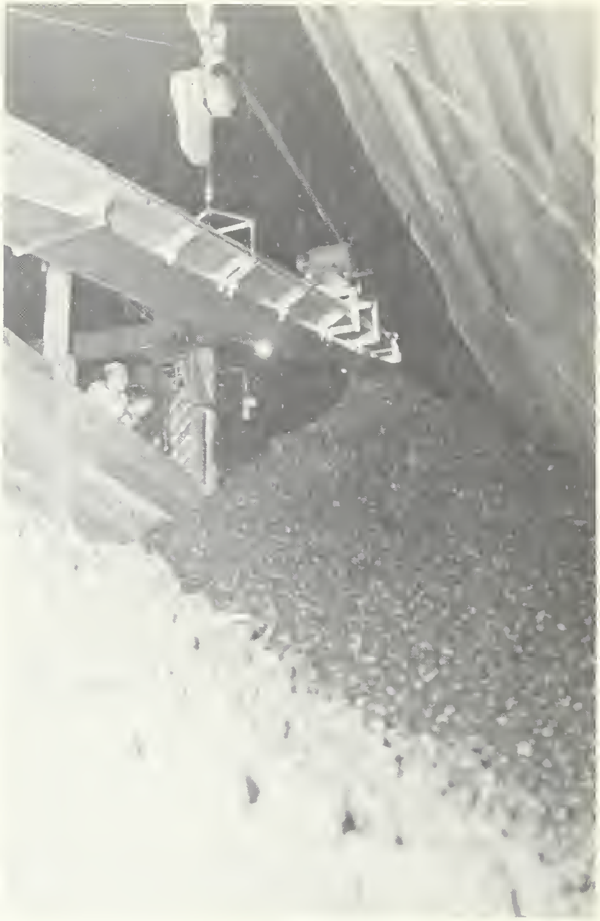

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Figure 4.--Lightweight, 40-foot conveyor supported by track, trolley, and hoist.

Operation of Conveyor

The conveyor is designed to handle 120 cwt. of potatoes (one bulk truckload) in 5 minutes of operating time at a belt speed of 250 feet per minute. Receiving potatoes from a self-unloading bulk truck that can be emptied in about 7 minutes, the conveyor usually takes about 10 minutes to place a load into storage.

Figures 5 through 14 show the operating procedure used with this conveyor.

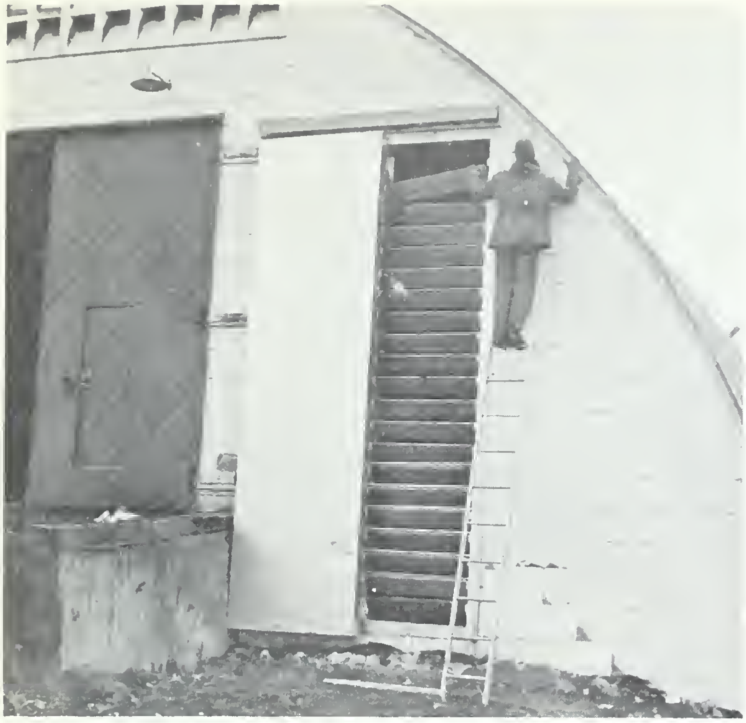

Figure 5.--First the insulated door is rolled back and retaining boards are removed.

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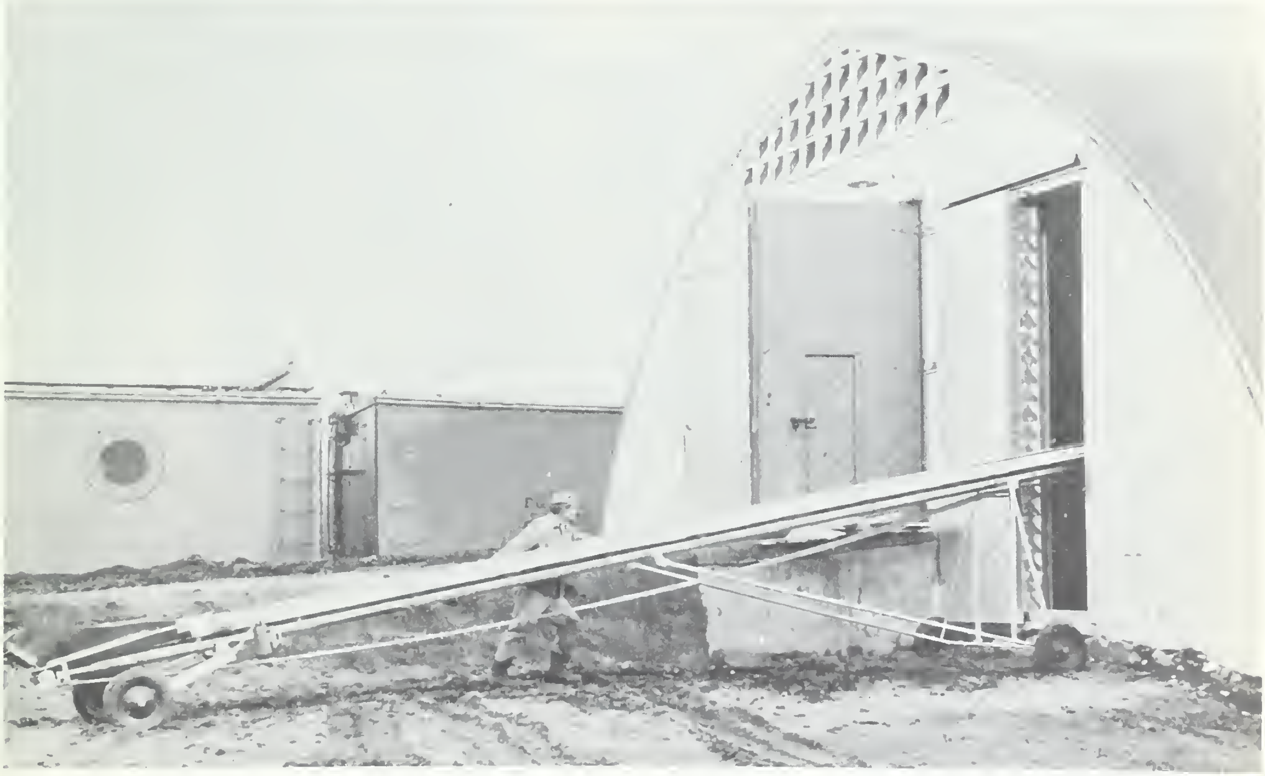

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Figure 6.--The conveyor is then moved through the opening.

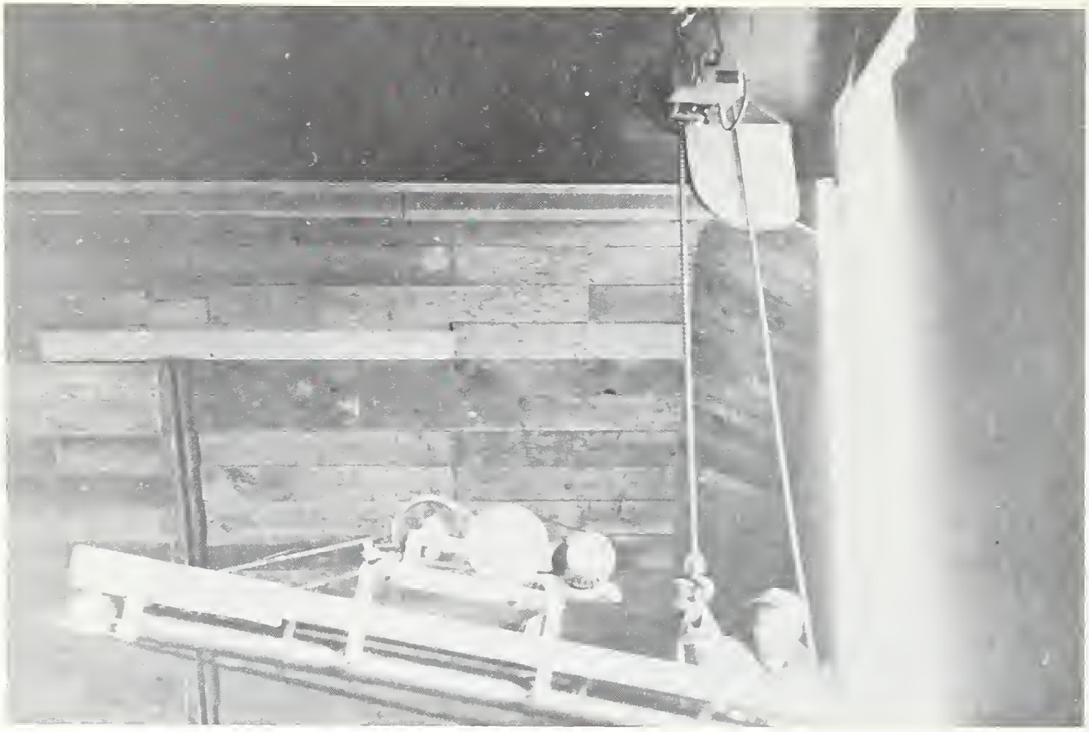

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Figure 7.--The hook from electric hoist is attached to the bail.

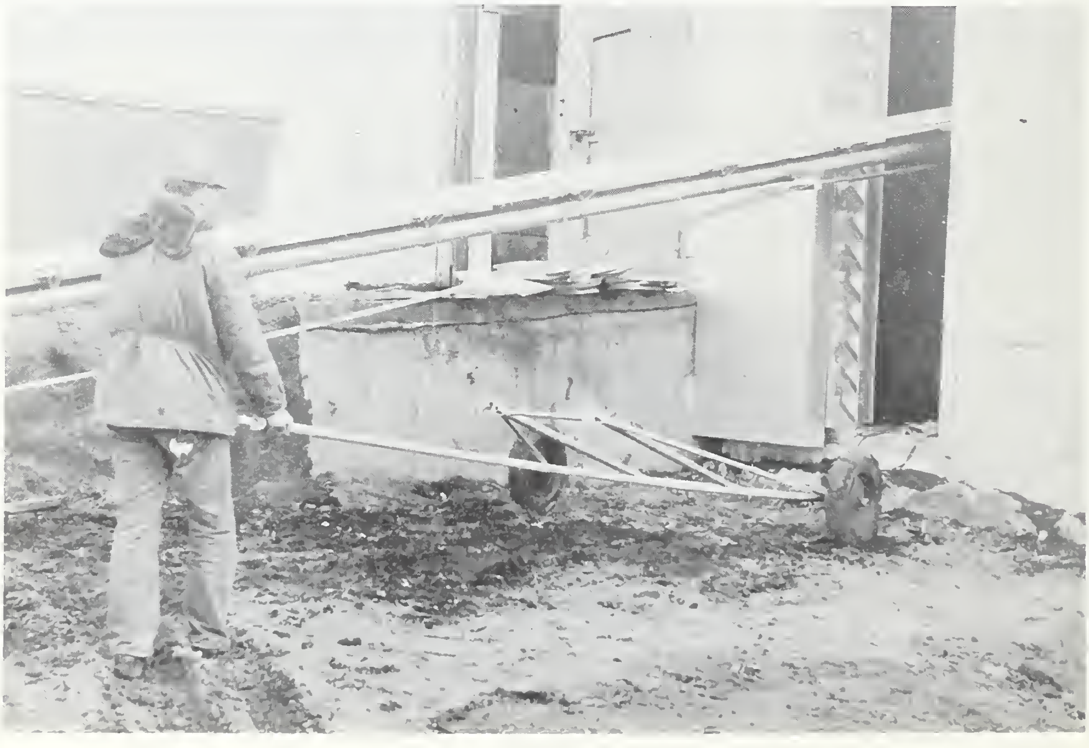

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Figure 8.--The conveyor is raised slightly with the hoist, and the front end support is removed.

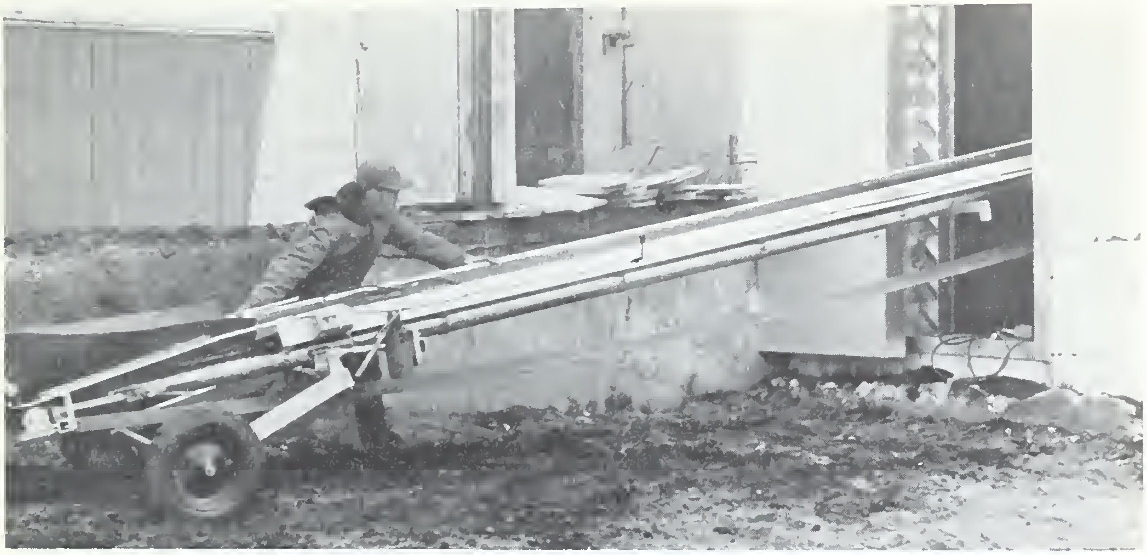

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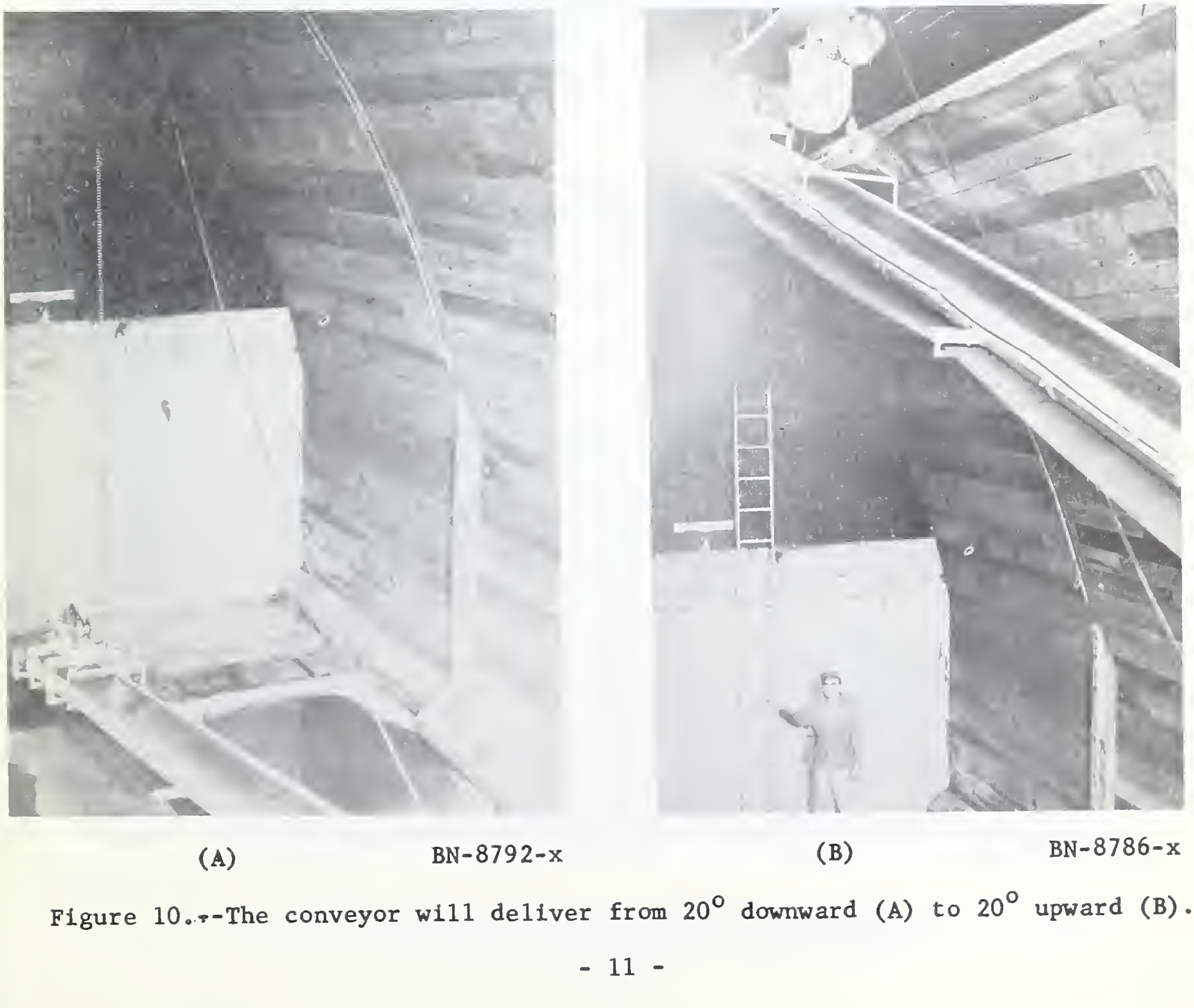
Figure 9.--The conveyor is pushed all the way into the storage.



(A) BN-8792-x

(B) BN-8786-x

Figure 10.--The conveyor will deliver from 20° downward (A) to 20° upward (B).

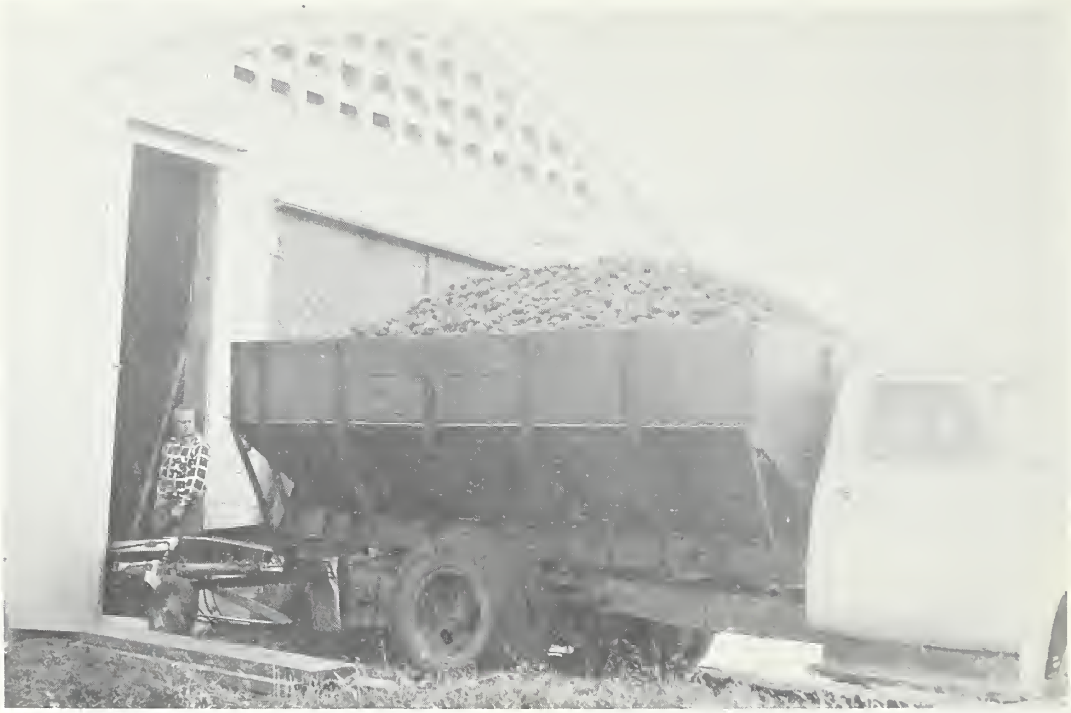


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Figure 11.--The hopper-body bulk truck with unloading conveyor delivers potatoes from the truck into the flexible hopper of the lightweight conveyor.

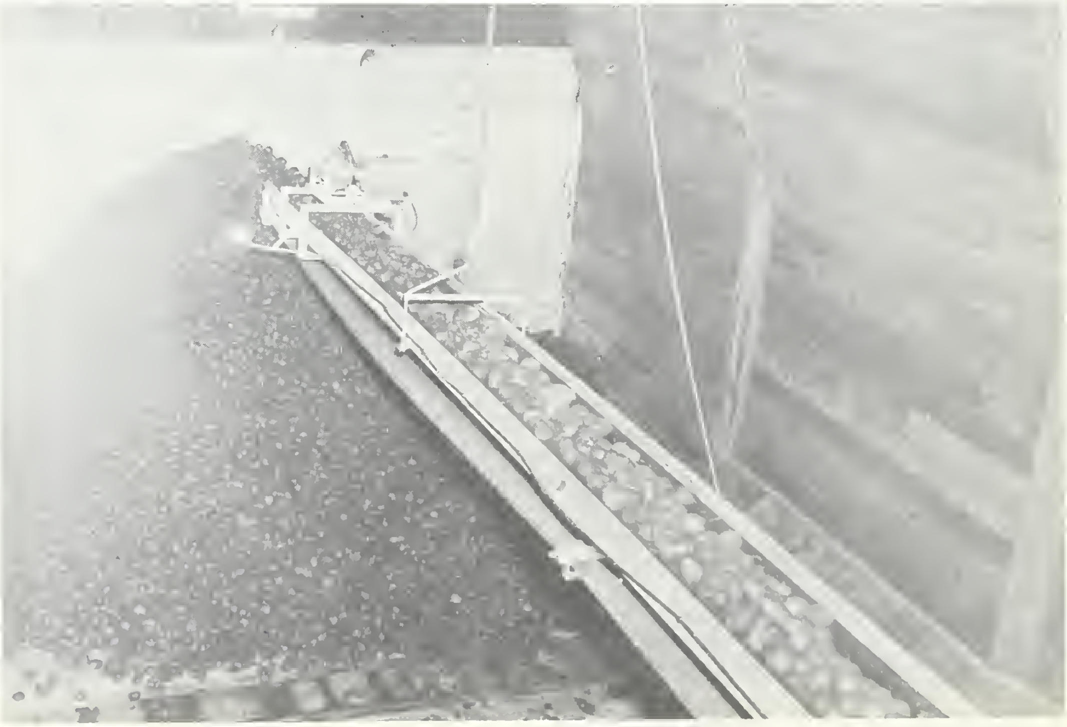

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Figure 12.--The pile of potatoes is built up until conveyor is level, then conveyor is withdrawn a few feet between loads.

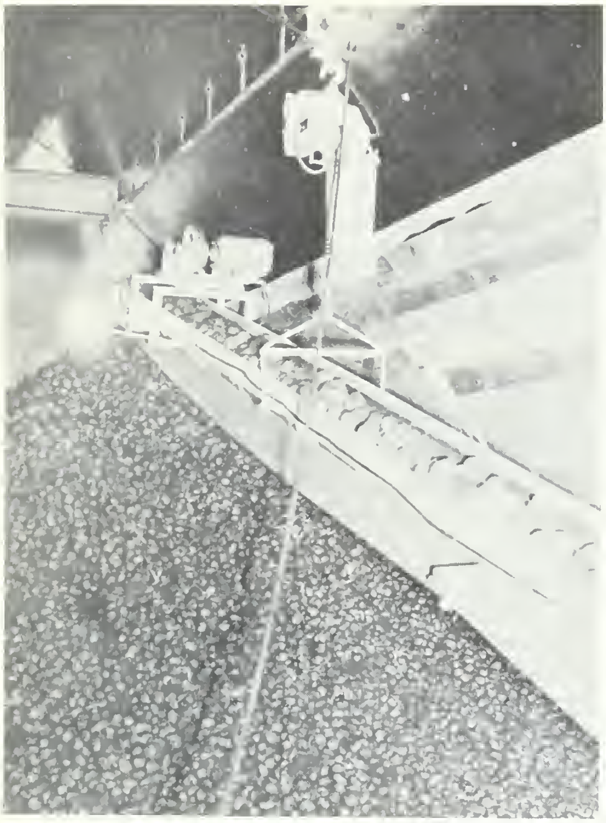

Figure 13.--When bottom part of storage is filled, the conveyor is run all the way in and potatoes are piled to the track or maximum height possible with the conveyor.

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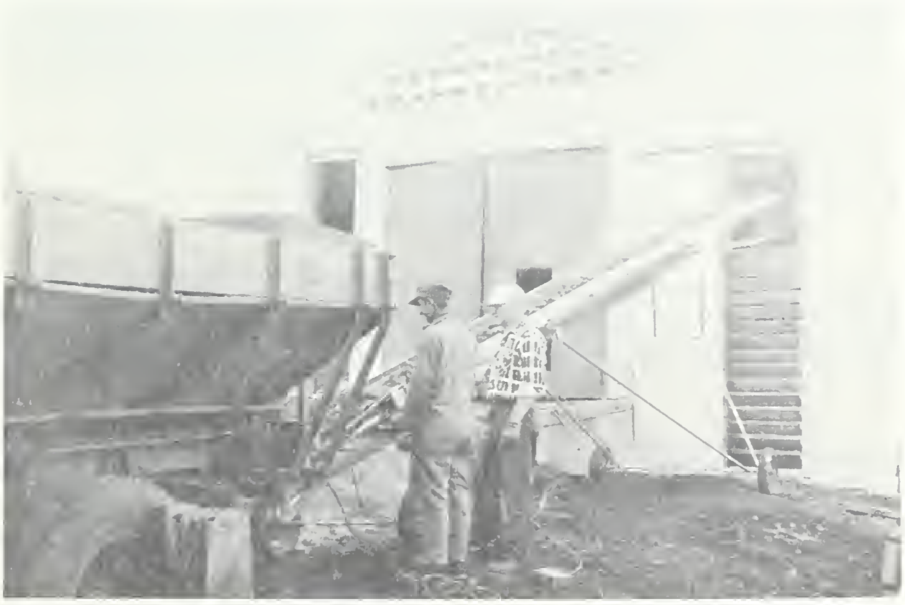

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Figure 14.--The front end support is attached to the conveyor and retaining boards are installed to complete filling the storage.

Construction Details

Figures 15 through 26 show construction details of the 40-foot conveyor.

A 40-foot-long tube, of 11 gage steel with an outside diameter of 5 inches, serves as a spine. The accessory parts are all clamped onto it or slid into the ends. Clamps are made from 5½-inch steel tubing cut off in bands of the required width which are then cut into two semicircles. Ears are welded to the bands, which can then be bolted tightly around the tube after accessories such as rollers, yokes, and motor mounts are welded to them.

The front and back yokes and rollers and the belt tightener are welded to short lengths of tubing (4-3/4-inch outside diameter, 11 gage) which fits inside the 40-foot spine. An automobile bumper jack of conventional design is modified to serve as an efficient belt tightener.

Construction Materials

The following materials constitute the major-cost items used for the experimental model which was built by contract. Specific manufacturers are mentioned solely for the purpose of clearly defining the characteristics of a material or part. Such mention does not imply preference. Equivalent material or products are acceptable in all instances.

Steel tubing: SAE 1050 cold-drawn seamless steel, unannealed, with 85,000 p.s.i. yield point, 100,000 p.s.i. ultimate strength, Brinell hardness 212, Rockwell B 95, all minimum values. Permissible variations in I.D., O.D., wall thickness, and out-of-round will not exceed the tolerances listed for Pittsburgh seamless steel mechanical tubing manufactured by Pittsburgh Steel Co., Pittsburgh, Pa.

One 40' piece 5" O.D. 11 BWG (6.254 lb./ft.)	250.16 lb.
One 5' piece 5½" O.D. x 3/16 (10.67 lb./ft.)	53.35 lb.
One 2' piece 4-3/4" O.D. x 11 BWG (5.934 lb./ft.).	11.87 lb.

Conveyor belt: Equivalent to the two-ply belting manufactured by Globe Woven Belting Co., Inc., 1400 Clinton Street, Buffalo, N. Y., and identified by that manufacturer as 16"-wide neoprene No. 202. It will be 83'-6" long, vulcanized endless.

Belt support rollers: Lamson Corp., 505 LaSalle Street, Chicago 10, Ill. 1¼" dia. No. 18 gage Lamson conveyor rollers, 6" long, 3/8" Snaplock shaft (or equivalent), 26 required; 1¼" dia. No. 18 gage Lamson conveyor roller, 17" long, 3/8" Snaplock shaft (or equivalent), 2 required.

Motor and speed reducer: 2 h.p., 220 v. 3-phase, 60-cycle AC motor and speed-reducing mechanism to turn the conveyor drive pulley at 150 r.p.m.

Switch and electrical wire: Heater switch to protect motor from overload damage; 3-wire, rubber-covered weatherproof electric cable, approximately 40 feet attached at 3-foot intervals to side rail of conveyor;

approximately 40 feet to be used as extension cord with male plug attached; total, 80 feet of wire.

Wheels and tires: Metal wheels, 1-inch bore roller bearing hub, approximately 14" O.D. pneumatic tires.

Miscellaneous: All other materials used will be of good quality, of dimensions as specified in figures 15 to 26. The finished conveyor will be sprayed with one coat of aluminum paint on properly prepared surfaces.

CONCLUSIONS AND RECOMMENDATIONS

It is particularly important that high-strength steel as specified for the tubing be used. This material was chosen over mild steel to reduce weight. The spine method of construction was used to reduce fabrication cost.

If standard pipe is used for the spine, it will fail under load. The high-strength steel tubing deflects as may be seen from the figures, but does not take a permanent set.

During operation it is necessary to place a rolled-up, empty burlap bag behind the last of the potatoes to empty the conveyor and prevent rollback, if there is even a slight upward slope. There is no rollback even with a 20° incline when the hopper is kept continuously full.

Since the side rails do not extend above the troughed belt, the potatoes will not be scuffed during their trip along the conveyor. The design of the hopper prevents clogging the belt.

The drop from conveyor to pile is short because of the small drive-pulley and the absence of cleats or flights. The short drop helps to reduce injury to the potatoes.

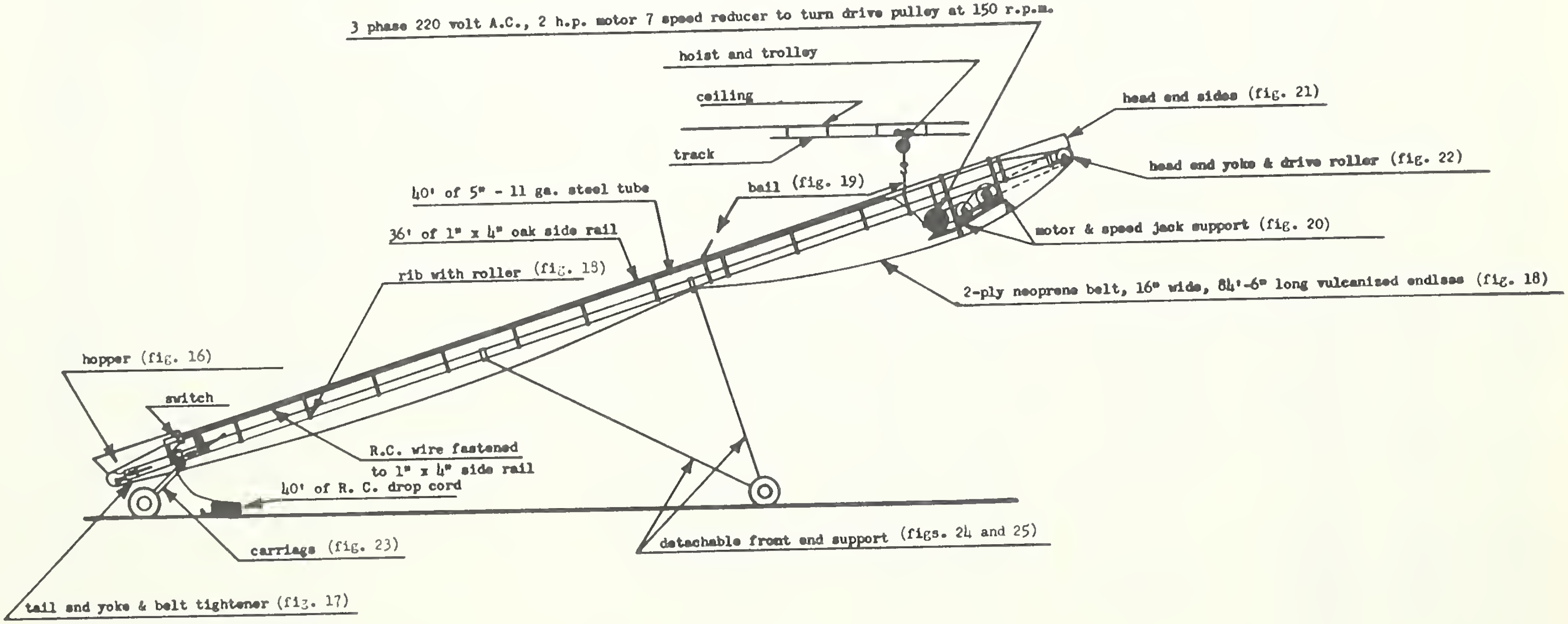

3 phase 220 volt A.C., 2 h.p. motor 7 speed reducer to turn drive pulley at 150 r.p.m.
hoist and trolley
ceiling
track
head end sides (fig. 21)
head end yoke & drive roller (fig. 22)
bail (fig. 19)
40' of 5" - 11 ga. steel tube
36' of 1" x 4" oak side rail
rib with roller (fig. 18)
motor & speed jack support (fig. 20)
2-ply neoprene belt, 16" wide, 84'-6" long vulcanised endless (fig. 18)
hopper (fig. 16)
switch
R.C. wire fastened to 1" x 4" side rail
40' of R. C. drop cord
carriage (fig. 23)
detachable front end support (figs. 24 and 25)
tail end yoke & belt tightener (fig. 17)

Figure 15.--Assembly drawing for lightweight 40-foot trough belt conveyor.

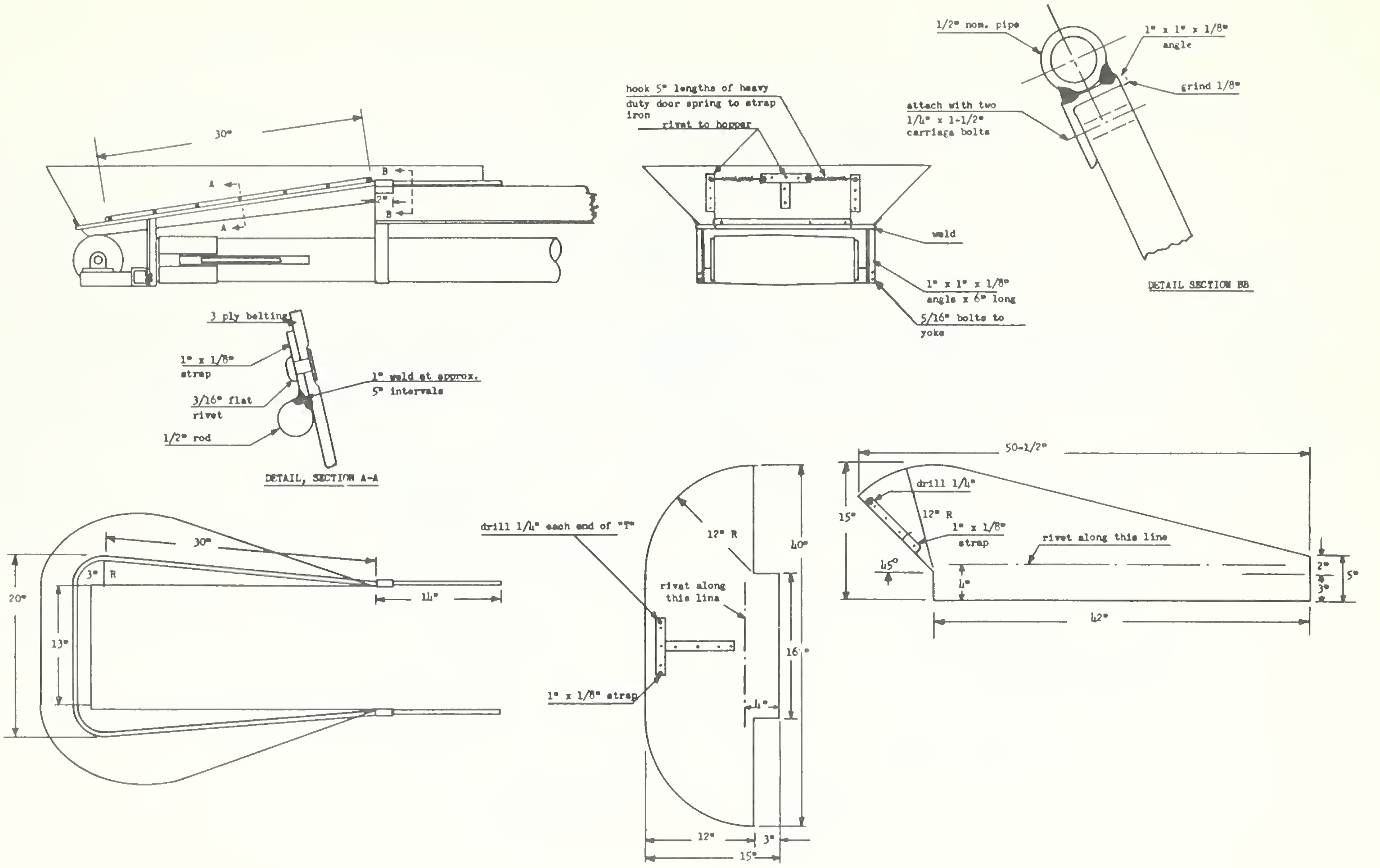


Figure 16.--Flexible hopper.

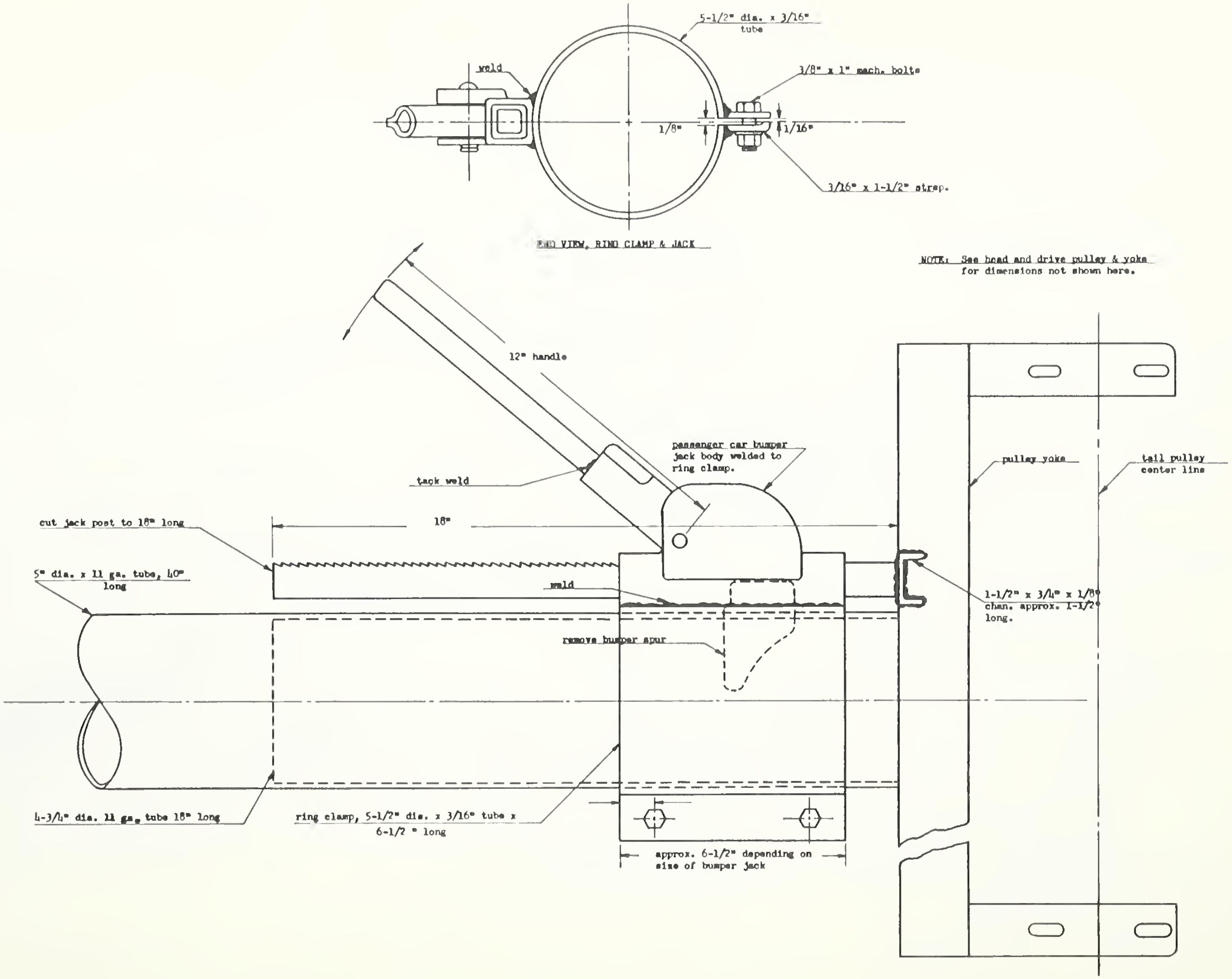

5-1/2" dia. x 3/16" tube
weld
3/8" x 1" mach. bolts
1/8"
1/16"
3/16" x 1-1/2" strap.
END VIEW, RING CLAMP & JACK
NOTE: See head and drive pulley & yoke for dimensions not shown here.
12" handle
passenger car bumper jack body welded to ring clamp.
pulley yoke
tail pulley center line
tack weld
cut jack post to 18" long
18"
5" dia. x 11 ga. tube, 40" long
weld
1-1/2" x 3/4" x 1/8" chan. approx. 1-1/2" long.
remove bumper spur
4-3/4" dia. 11 ga. tube 18" long
ring clamp, 5-1/2" dia. x 3/16" tube x 6-1/2 " long
approx. 6-1/2" depending on size of bumper jack

Figure 17.--Tail end yoke and belt tightener.

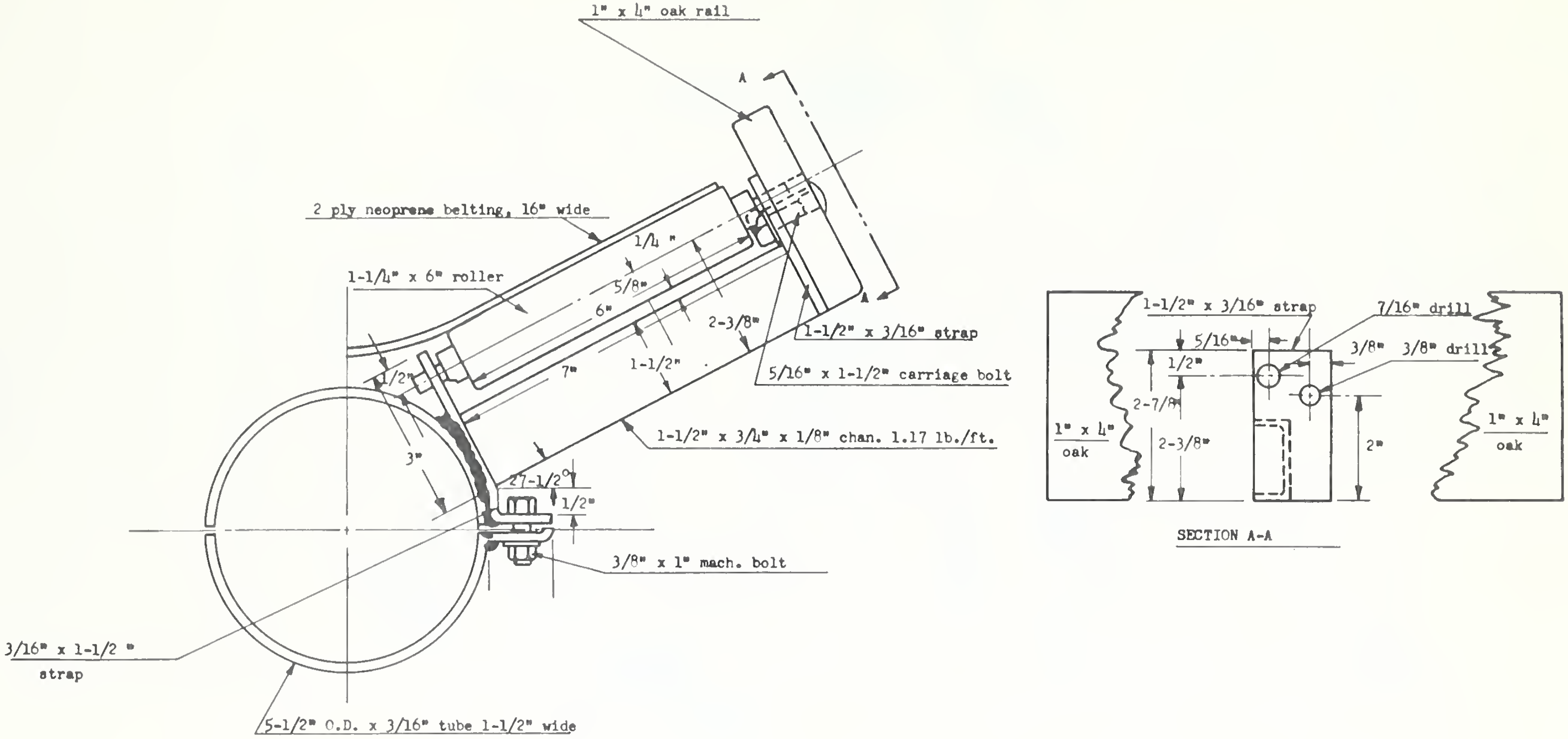


Figure 18.--Rib with roller.

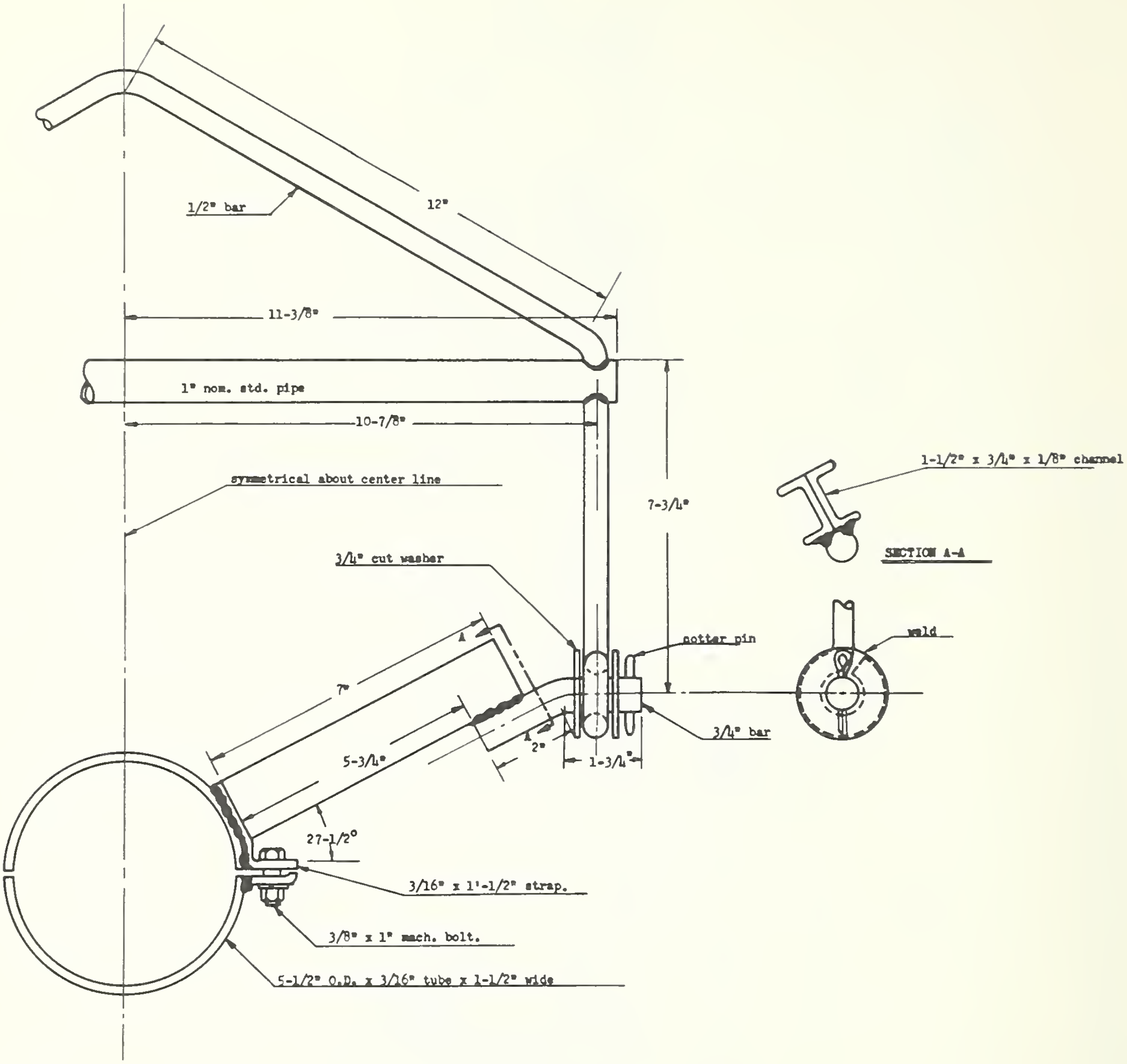
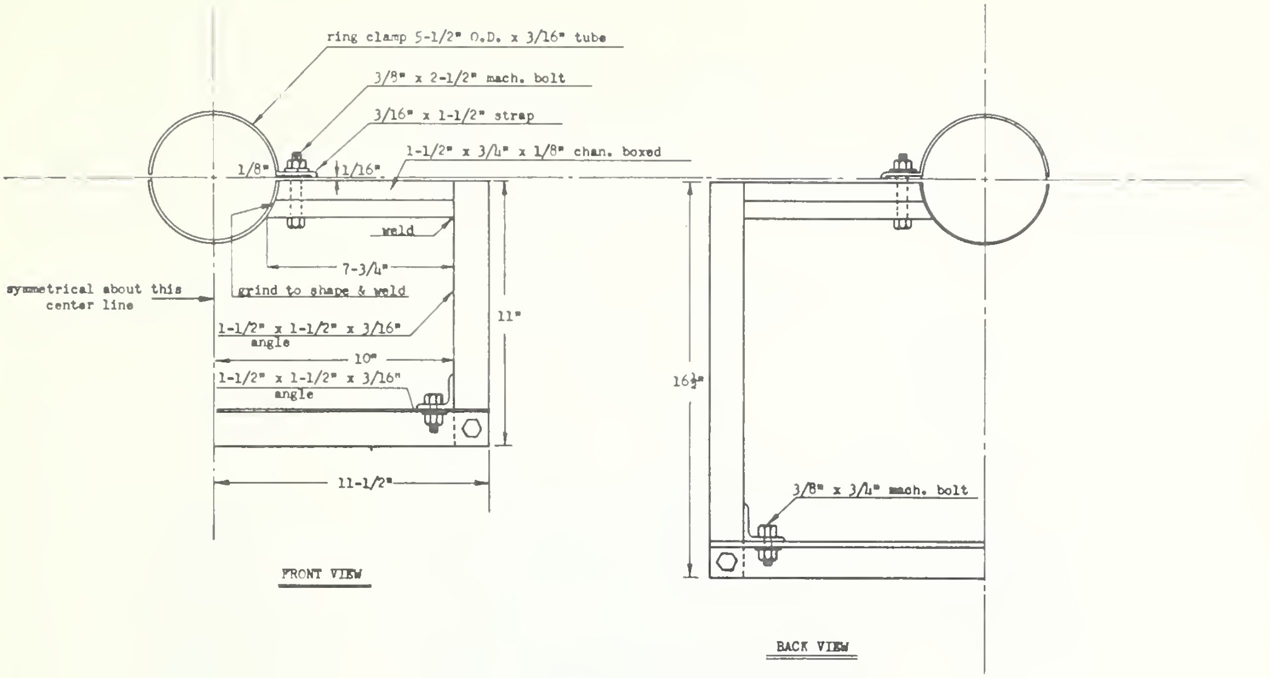
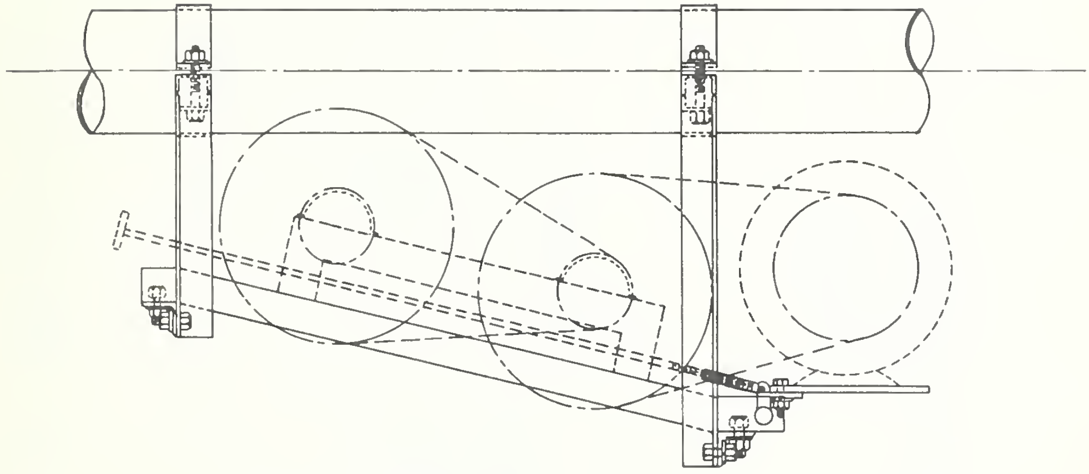


Figure 19.--Bail.


ring clamp 5-1/2" O.D. x 3/16" tube
3/8" x 2-1/2" mach. bolt
3/16" x 1-1/2" strap
1-1/2" x 3/4" x 1/8" chan. boxed
1/8"
1/16"
weld
7-3/4"
symmetrical about this center line
grind to shape & weld
1-1/2" x 1-1/2" x 3/16" angle
11"
10"
1-1/2" x 1-1/2" x 3/16" angle
11-1/2"
FRONT VIEW
16½"
3/8" x 3/4" mach. bolt
BACK VIEW



SIDE VIEW

Figure 20.--Motor and speed jack support.

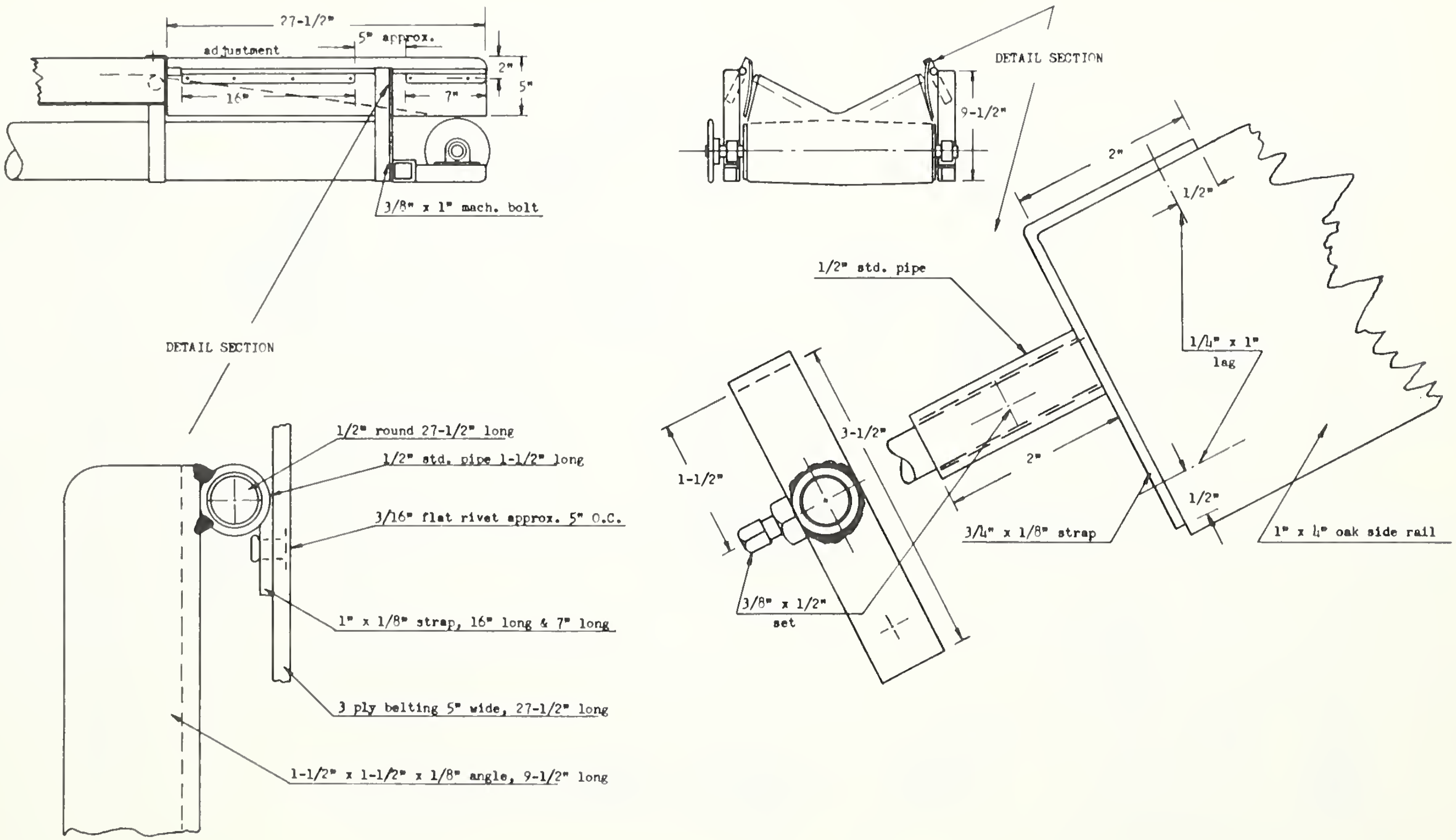


Figure 21.--Head end sides.

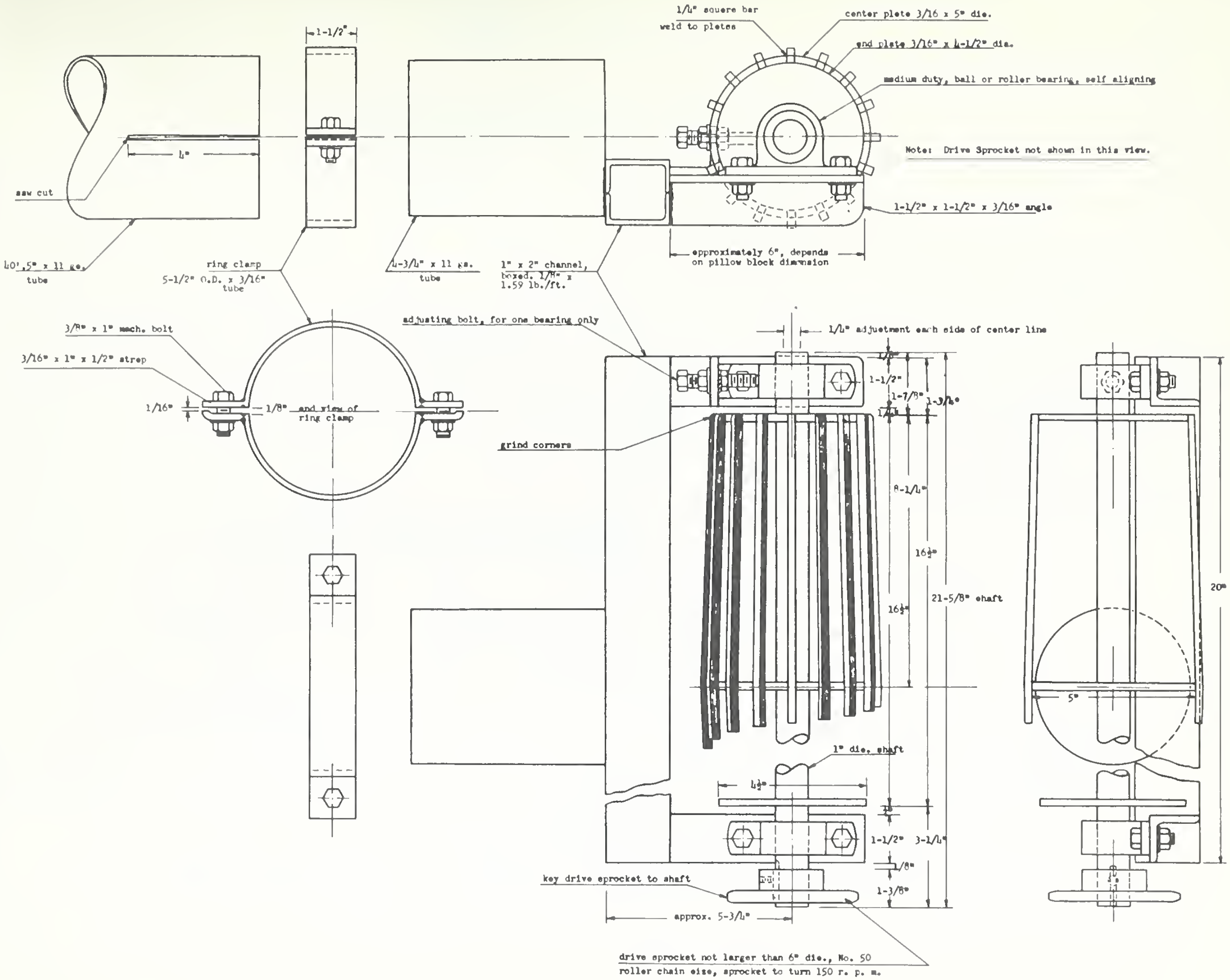

1/4" square bar
weld to plates
center plate 3/16 x 5" dia.
end plate 3/16" x 4-1/2" dia.
medium duty, ball or roller bearing, self aligning
Note: Drive Sprocket not shown in this view.
1-1/2" x 1-1/2" x 3/16" angle
approximately 6", depends on pillow block dimension
1-1/2"
4"
saw cut
40',5" x 11 ga. tube
ring clamp 5-1/2" O.D. x 3/16" tube
4-3/4" x 11 ga. tube
1" x 2" channel, boxed, 1/8" x 1.59 lb./ft.
adjusting bolt, for one bearing only
1/4" adjustment each side of center line
3/8" x 1" mach. bolt
3/16" x 1" x 1/2" strap
1/16"
1/8"
end view of ring clamp
grind corners
1/2"
1-1/2"
1-7/8"
1-3/4"
1/4"
8-1/4"
16½"
16½"
21-5/8" shaft
20"
5"
1" dia. shaft
4½"
1-1/2"
3-1/4"
1/8"
1-3/8"
key drive sprocket to shaft
approx. 5-3/4"
drive sprocket not larger than 6" dia., No. 50 roller chain size, sprocket to turn 150 r. p. m.

Figure 22.--Head end yoke and drive roller.

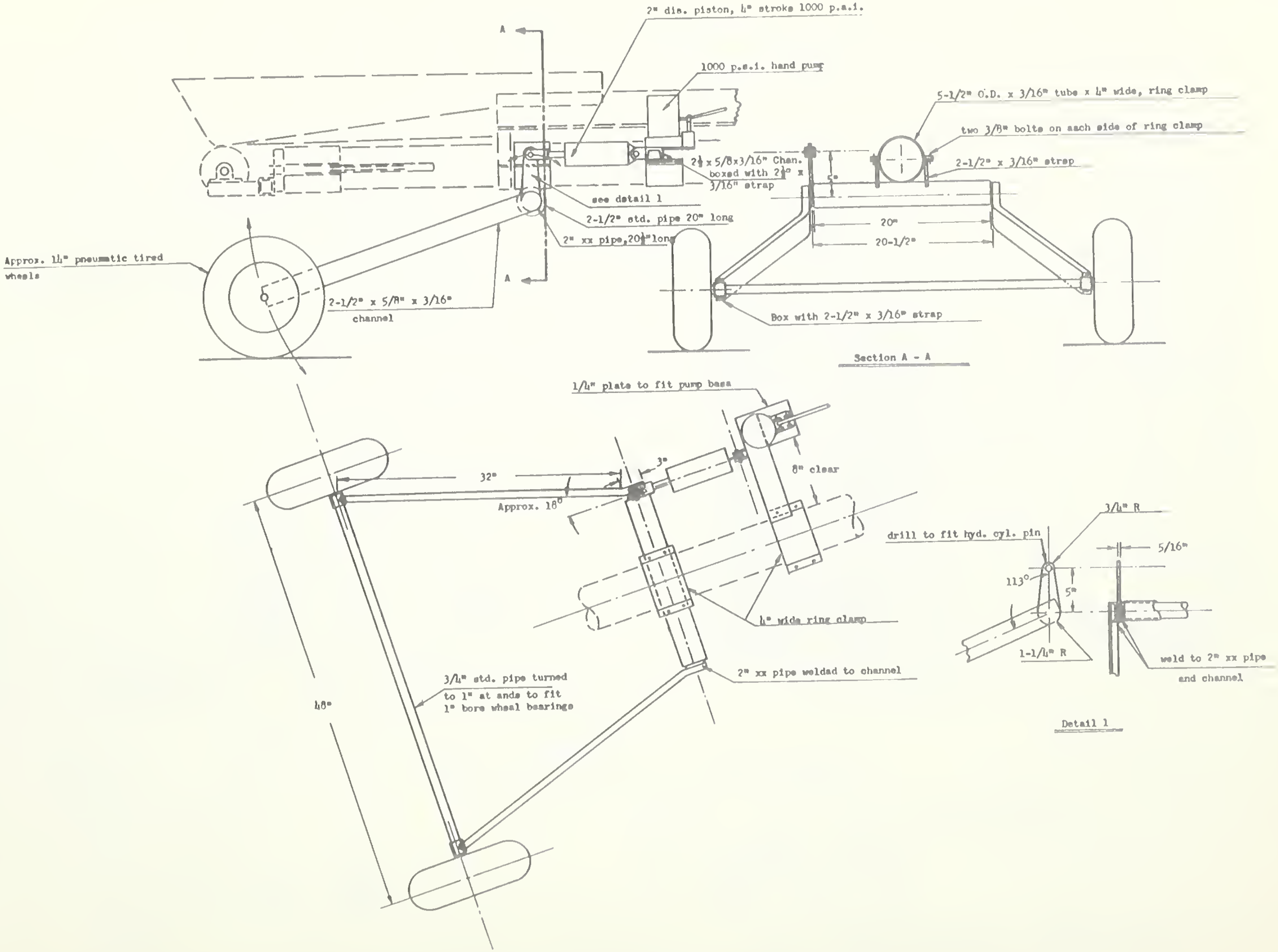

2" dia. piston, 4" stroke 1000 p.s.i.
A
1000 p.s.i. hand pump
5-1/2" O.D. x 3/16" tube x 4" wide, ring clamp
two 3/8" bolts on each side of ring clamp
2-1/2" x 3/16" strap
2¼ x 5/8x3/16" Chan. boxed with 2¼" x 3/16" strap
5"
see detail 1
2-1/2" std. pipe 20" long
2" xx pipe, 20¼" long
20"
20-1/2"
Approx. 14" pneumatic tired wheels
A
2-1/2" x 5/8" x 3/16" channel
Box with 2-1/2" x 3/16" strap
Section A - A
1/4" plate to fit pump base
3"
8" clear
32"
Approx. 18°
3/4" R
drill to fit hyd. cyl. pin
5/16"
113°
5"
4" wide ring clamp
1-1/4" R
weld to 2" xx pipe and channel
2" xx pipe welded to channel
3/4" std. pipe turned to 1" at ends to fit 1" bore wheel bearings
48"
Detail 1

Figure 23.--Carriage.

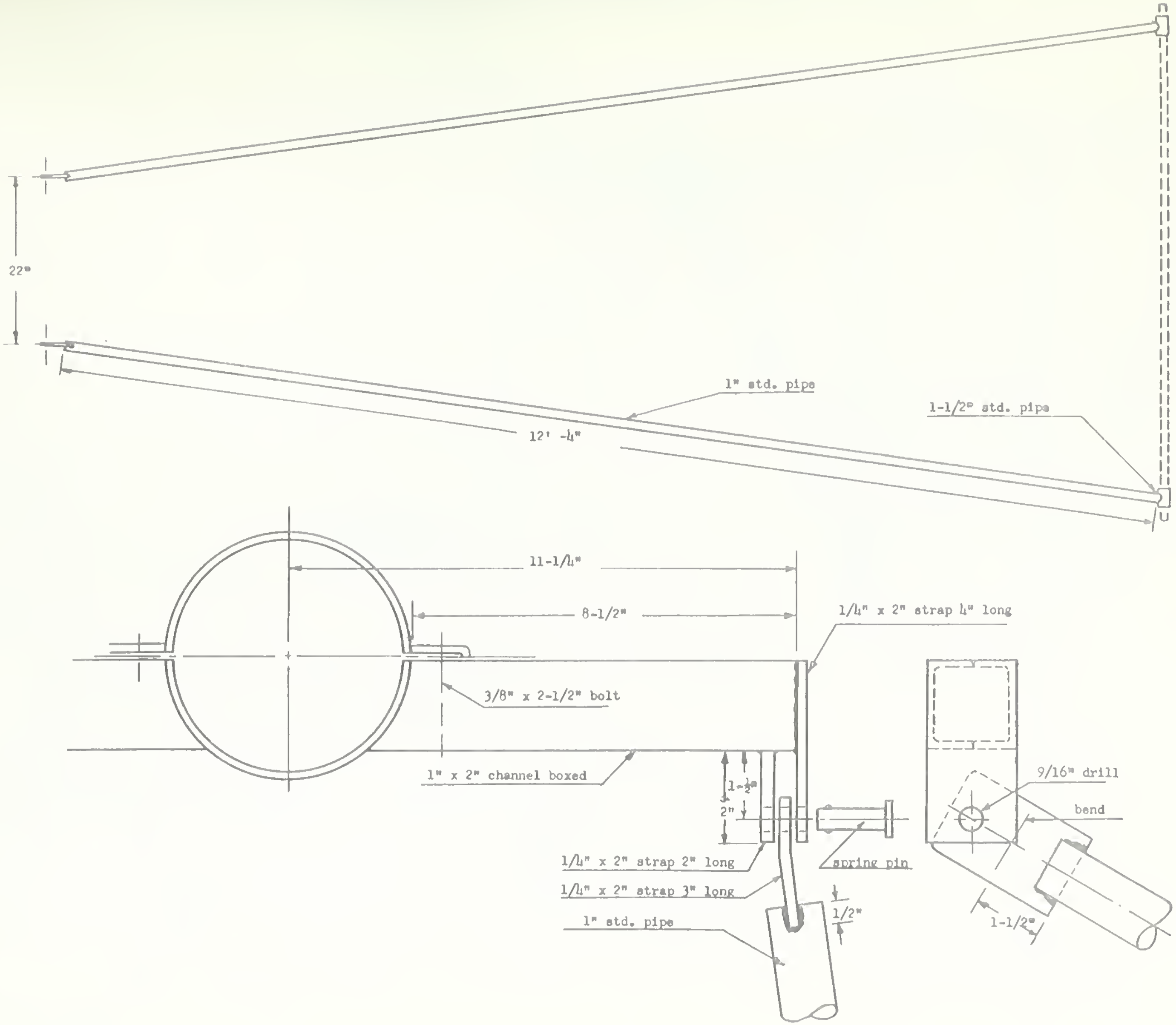


Figure 24.--Detachable front end support.

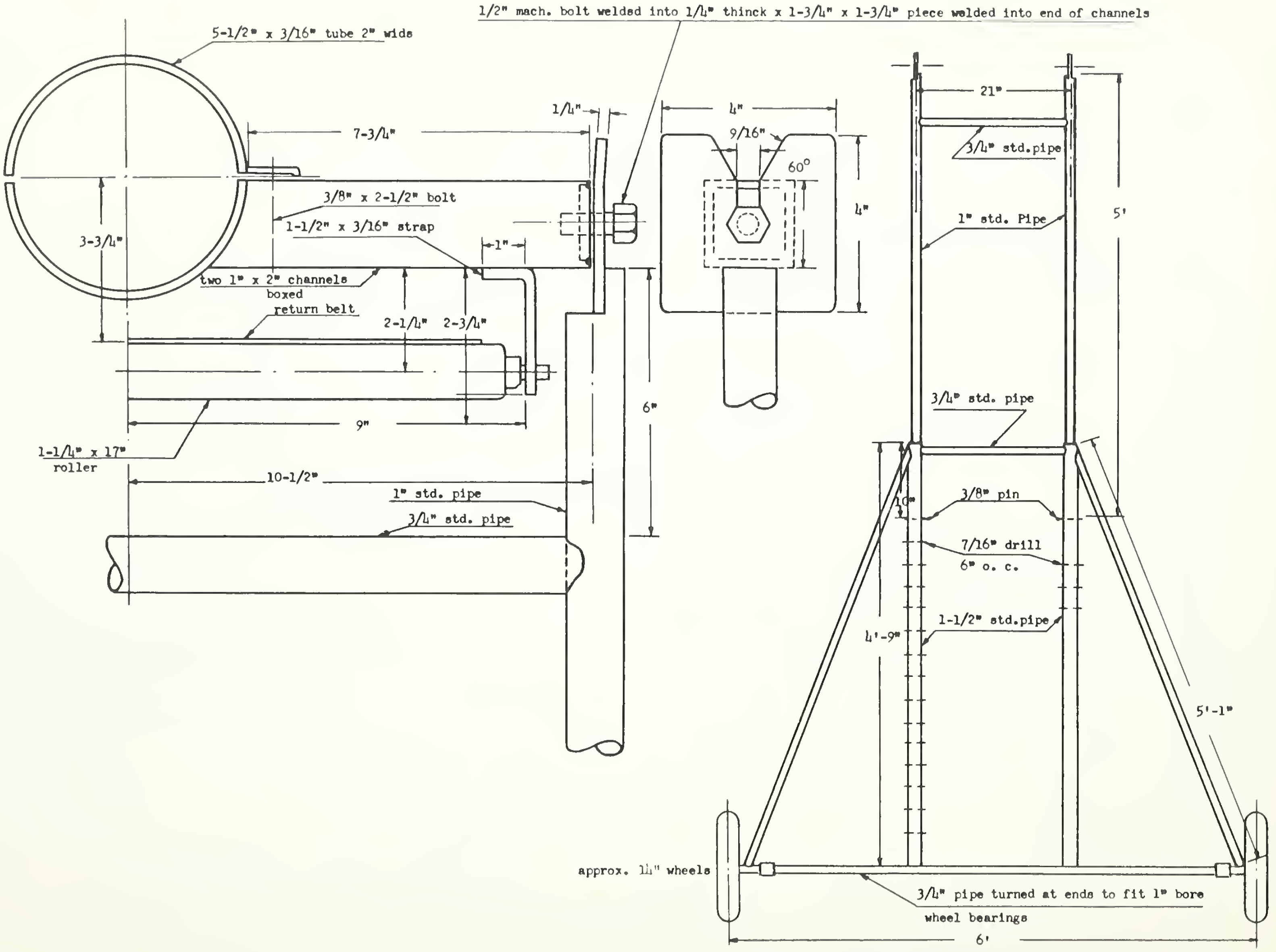


Figure 25.--Detachable front end support and return idler.

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